Global CO_2 transport simulations using meteorological data from the NASA data assimilation system

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[1] We present a first analysis of atmospheric CO_2 transport using meteorological data from the NASA finite volume data assimilation system (FVDAS). The analyzed meteorological fields are used along with climatological surface sources and sinks in an off-line, forward transport simulation for 1998–2000. Analysis of model diagnostics and comparisons to previous results indicates that the model performance is consistent with that of most previous global transport models. The model interhemispheric gradients along with the timing and magnitude of the CO_2 seasonal cycle are discussed, providing inferences regarding the northern biosphere, tropical land, and southern ocean fluxes. Global distributions of column-integrated CO_2 are presented to provide a basis for measurement requirements for the design of satellite-based instruments for atmospheric CO_2 column. On the synoptic scale we find a significant benefit in using the FVDAS analyzed winds for comparisons to data. At near-equatorial observation sites, the model correctly simulates the observed atmospheric composition transition associated with the latitudinal movement of the ITCZ. Comparison to daily data from continuous analyzer sites shows the model captures a substantial amount of the observed synoptic variability due to transport changes. These results show the potential to use high temporal and spatial resolution remote sensing data to constrain CO_2 surface fluxes, and they form the starting point for developing an operational CO_2 assimilation system to produce high-resolution distributions of atmospheric CO_2 and quantitative estimates of the global carbon budget. *INDEX TERMS:* 0315 Atmospheric Composition and Structure: Biosphere/atmosphere interactions; 0322 Atmospheric Composition and Structure: Constituent sources and sinks; 0368 Atmospheric Composition and Structure: Troposphere—constituent transport and chemistry; 3337 Meteorology and Atmospheric Dynamics: Numerical modeling and data assimilation; *KEYWORDS:* carbon dioxide, data assimilation

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1. Introduction

[2] CO_2 emissions, primarily from fossil fuel burning, are the largest anthropogenic climate driver and will be for the coming decades to centuries [*Intergovernmental Panel on Climate Change* (*IPCC*), 2001]. In order to make accurate projections of future atmospheric CO_2, we need to understand what controls the highly variable atmospheric CO_2 concentrations, the role of various surface sources and sinks in the global carbon cycle, and the mechanisms through which CO_2 sources and sinks interact with changing climate. Currently, significant uncertainties are attached to our understanding of these processes [*IPCC*, 2001; *Schimel et al.*, 2001]. Resolving these issues is critical to reliable predictions of future climate forcing and effective remedial/preventative actions.

[3] The global distribution of CO_2 surface fluxes is commonly inferred from transport models and atmospheric concentration measurements (inverse modeling) [*Enting and Mansbridge*, 1991; *Fan et al.*, 1998; *Bousquet et al.*, 1999]. This approach is limited by the accuracy of the numerical transport model, the circulation/wind inputs that drive the transport, and the observational CO_2 data. Transport model differences have been a major source of variation in the inference of CO_2 sources and sinks [*Law et al.*, 1996; *Denning et al.*, 1999; *Gurney et al.*, 2002; *Peylin et al.*, 2002]. The TransCom project [*Gurney et al.*, 2002, and references therein] is an international effort to quantify the errors introduced into our understanding of the carbon cycle by differences/errors in the circulations and transport computed by models. The work reported here uses the transport core and meteorological analyses from a state of the art data assimilation system to produce 3-D atmospheric CO_2 distributions based on TransCom emission scenarios.

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